INSTRUCTION MANUAL

INSTRUCTION MANUAL
FOR
SHIELDED ENCLOSURE
LEAK DETECTION SYSTEM
MODEL 500

MANUAL NO. 1-500783-172

SINGER
INSTRUMENTATION

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SINGER
INSTRUMENTATION

The Singer Company, Los Angeles Operation • 5340 Alla Road, Los Angeles, Ca. 90066

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2. Serial Number
3. Description of trouble(1)
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Has maintenance action been previously requested.
7. Other comments.

(1) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

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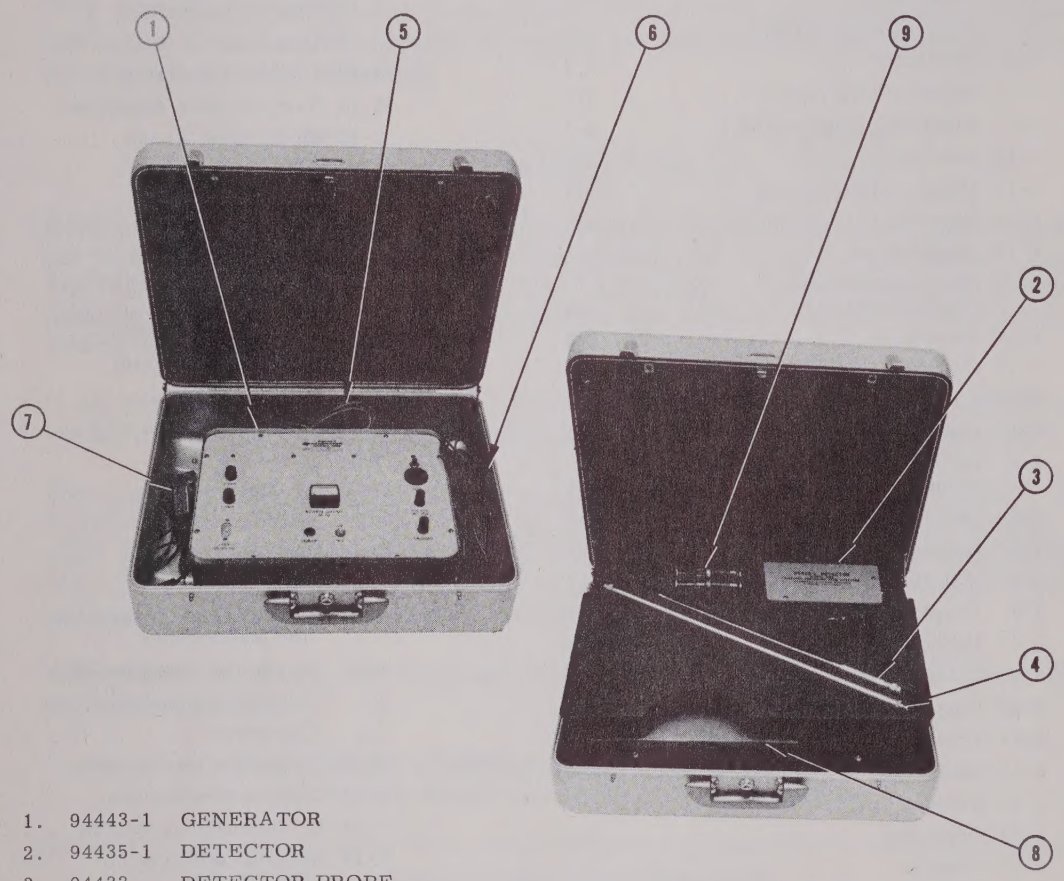


1. 94443-1 GENERATOR
2. 94435-1 DETECTOR
3. 94433 DETECTOR PROBE
4. 94432 DETECTOR PROBE EXTENSION
5. 12644 AC POWER CABLE
6. 94438-2 40-FOOT OUTPUT CABLE
7. 94438-1 5-FOOT OUTPUT CABLE
8. 40623 INSTRUCTION MANUAL
9. - - - - BATTERY SET

Figure 1-1. STODDART Model 500 Shielded Enclosure Leak Detection System

SECTION I

DESCRIPTION AND LEADING PARTICULARS

1-1. INTRODUCTION

1-2. SCOPE. This manual contains operation and maintenance instructions for the Model 500 Shielded Enclosure Leak Detection System, manufactured by STODDART ELECTRO SYSTEMS, Gardena California 90249. The manual is divided into five sections; i.e., Description and Leading Particulars, Operating Instructions, Principles of Operation, Maintenance, and Parts List.

1-3. PURPOSE. The Model 500 Shielded Enclosure Leak Detection System has been designed to detect and pin-point sources of RF leakage in a shielded enclosure. Through use of the system during the final stages of enclosure assembly, and periodic monitoring thereafter, MIL-Spec RF shielding compliance can be assured.

1-4. GENERAL DESCRIPTION

1-5. The Model 500 Shielded Enclosure Leak Detection System comprises two basic units; i.e., the generator, and the detector. The complete system is illustrated in Figure 1-1, and the equipment supplied is tabulated in Table 1-1.

Table 1-1. Equipment Supplied

ITEM	PART NO.	DESCRIPTION
1	94437	Generator and transit case
2	94435	Detector
3	94433	Detector probe
4*	94432	Detector probe extension
5	53297	Detector pistol grip
6	- - -	Generator cable set; consists of:
	12644	AC power cable
	94438-1	Generator output cable, 5-foot
	94438-2	Generator output cable, 40-foot
7	40623	Instruction manual
8	- - -	Battery set (Refer to Table 1-2)

* Optional accessory item

1-6. GENERATOR

1-7. PHYSICAL DESCRIPTION. The generator and system transit case (Figure 1-2) is an integral assembly, providing all necessary storage space for the remaining items of the complete system. The transit case is a standard aluminum travel case, and measures 17 by 21 by 8 inches.

1-8. The generator proper, is mounted on the bottom of the case interior. Sufficient space is provided around the generator to store the cables required for system operation. A hinged aluminum plate protects the generator when not in use, or during transit. A form fitted foam insert, on the top of the hinged plate, contains the detector unit, probe, probe extension, and instruction manual.

1-9. ELECTRICAL DESCRIPTION. The generator is of completely solid-state design, and produces a 106 kHz output signal. The 106 kHz output is in turn pulse modulated by a 600 Hz tone to provide an aural response from the detector. The generator has been designed to provide a constant current output of approximately one ampere into the external load (the shielded enclosure), and requires no tuning, or other adjustments prior to use. The generator operates from a 115 volt, 50 to 60 Hz AC power source.

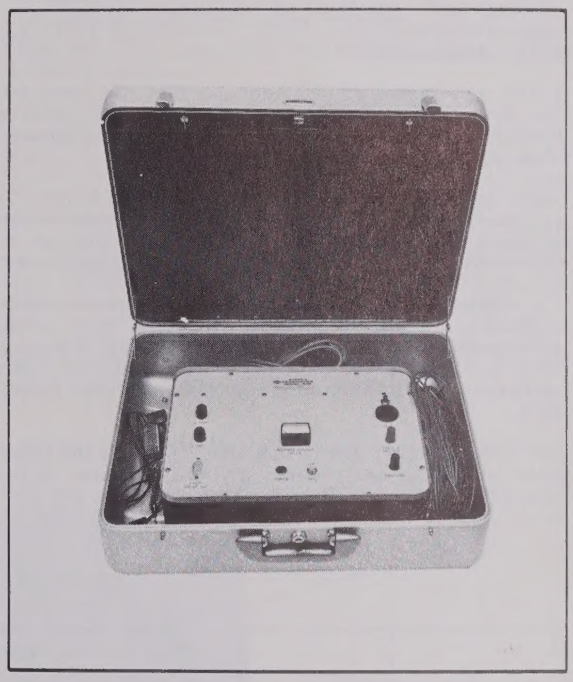


Figure 1-2. Generator and Transit Case Assembly

1-10. DETECTOR

1-11. PHYSICAL DESCRIPTION. The detector (Figure 1-3), is designed for hand-held operation. The probe is detachable for storage and transit. The detector (without probe installed) measures 7-1/4 by 7-3/8 by 2-1/2 inches. An internal lighting circuit is provided, permitting both the meter scale, and the area being searched with the probe to be illuminated where the ambient light level is low. All operating controls and indicators (except the actuating switch) are located on the rear of the case for ease of operation. A 20 inch probe extension is also available, permitting access to areas beyond normal reach by the operator.

1-12. ELECTRICAL DESCRIPTION. The detector is of completely solid-state design, and operates from an internal battery supply. Integrated circuits are employed for all functions, and provision is included for both aural and visual monitoring of the output. Aural monitoring is via an internal speaker, however a headset may be used if desired (automatically silencing the speaker). Visual monitoring is via a meter, calibrated in dB units for relative measurements. An ATTENUATOR is included, inserting up to 60 dB attenuation in 10 dB steps, and an AUDIO gain control is also provided.

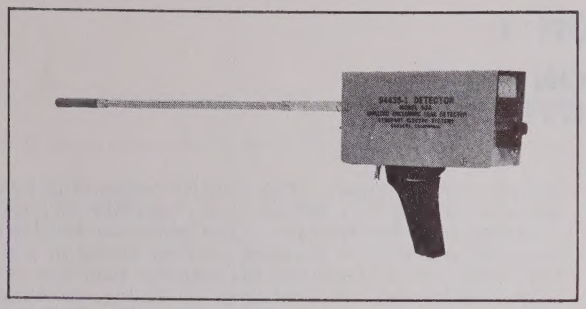


Figure 1-3. Detector Unit

1-13. APPLICATION

1-14. The Model 500 system permits the detection and pin-pointing of defects that permit RF leakage between 14 kHz and 10 GHz in a shielded enclosure. This is accomplished as follows:

a. The 106 kHz output from the generator is directly connected to opposing corners on the outside of the shielded enclosure. This causes an RF current to flow through the entire outer surface of the enclosure.

b. When the sheath of RF current encounters a discontinuity in the outer surface, such as a "dirty" seam (where two corners join), or any opening, a strong magnetic field is set up vertical to the current flow, and penetrates into the interior of the shielded enclosure.

c. The detector unit is then used to probe the inner surfaces of the enclosure, and will respond to the magnetic component "leakage" through from the exterior.

1-15. CHARACTERISTICS AND SPECIFICATIONS

1-16. GENERATOR. The generator has the following characteristics and specifications:

a. Frequency of Operation: The frequency of operation is 106 kHz.

b. Output Signal: The output signal is pulse modulated at approximately a 600 Hz PRF, and has a 50-percent duty cycle.

c. Output Level: The nominal output level is maintained at one ampere (RMS) into an inductive load from approximately 5 to 50 microhenries.

d. Output Control: Automatic output current level control by current sampling loop.

e. Power Requirements: 115 volts, 50 to 60 Hz.

1-17. DETECTOR. The detector has the following characteristics and specifications:

a. Frequency of Operation: The frequency of operation is 106 kHz.

b. Outputs: Two; i.e., aural (600 Hz tone) and indicating meter (0 to 20 dB scale).

c. Dynamic Range: Approximately 80 dB.

d. Attenuator Range: 60 dB in 10 dB steps.

e. Power Requirements: The detector requires one 9-volt, and one 3-volt power source. Several types of batteries may be used; i.e., mercury, alkaline, zinc-carbon, etc. The battery holders will accept cells up to 0.67 inches diameter, and from 3.90 to 4.55 inches in length. A tabulation of typical batteries meeting these requirements is presented in Table 1-2.

Table 1-2. Typical Batteries

BATTERY TYPE	NOMINAL LIFE	±9 VOLTS		3 VOLTS	
		MANUFACTURER AND TYPE	NUMBER REQ.	MANUFACTURER AND TYPE	NUMBER REQ.
Mercury	Long	Mallory TR136	1	Mallory ZM9	2
		Burgess HG-1R	1	Burgess HG-12	2
		Mallory TR133	2		
		Burgess HG-1	2		
Alkaline	Medium	Burgess APX-21	2	Burgess AL-9	2
Zinc-Carbon	Short			Burgess 910, 920, or 930	2
				Eveready 1015E or 915BP	2
				Ray-O-Vac 15 or 7R	2
				RCA VS334	2

SECTION II
OPERATING INSTRUCTIONS

2-1. GENERAL

2-2. This section covers operation of the STODDART Model 500 Shielded Enclosure Leak Detection System. The system consists of two basic units, an RF generator, and a detector unit.

2-3. OPERATING CONTROLS, INDICATORS, AND RECEPTACLES

2-4. GENERATOR (Figure 2-1). All operating controls, indicators, and receptacles, are located on the front panel of the generator (accessible beneath the hinged aluminum plate in the system transit case). The function of each of these controls, indicators, and receptacles, is as follows:

a. 115 V 50/60 Hz Receptacle: The 115 V 50/60 Hz receptacle, J101, provides for connection of the AC Power Cable to the system.

b. AC 2 AMP Fuse: The AC 2 AMP fuse, F101, is in series with the primary side of the generator power transformer.

c. DC 2 AMP Fuse: The DC 2 AMP fuse, F102, is in series with the +60 volt DC bus from the power supply in the generator.

d. POWER Indicator: The POWER indicator, I101, is illuminated when 115 volt 50 to 60 Hz AC power is applied to the generator.

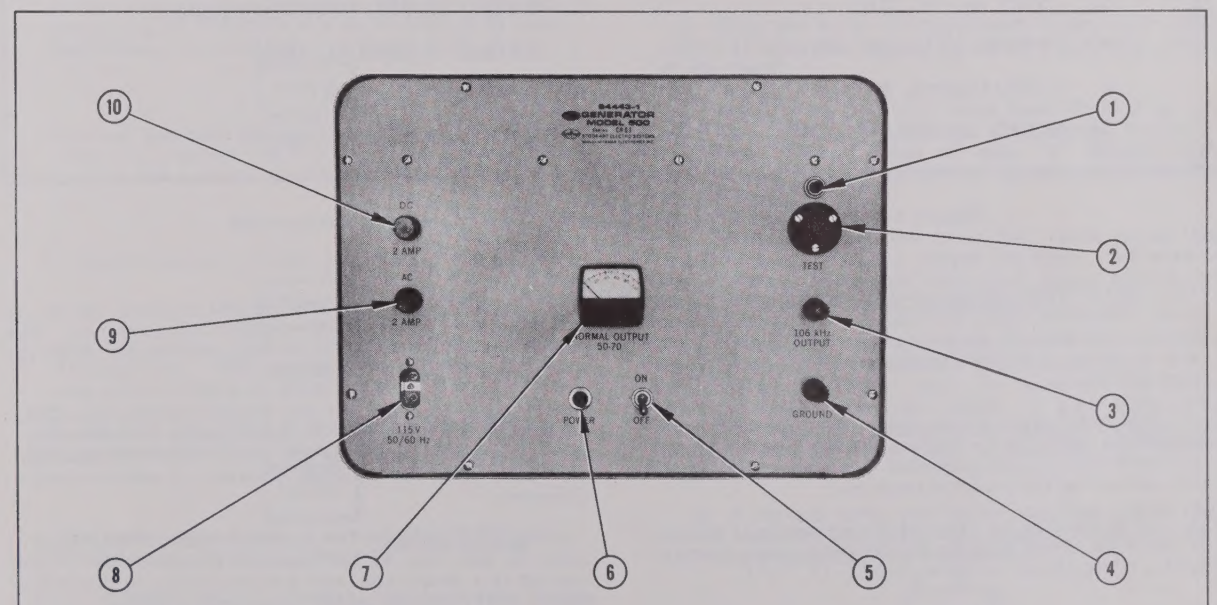
e. ON-OFF Switch: The ON-OFF switch, S101, applies the 115 volt 50 to 60 Hz AC power to the generator in the ON position.

f. NORMAL OUTPUT 50-70 Meter: The NORMAL OUTPUT 50-70 meter, M101, monitors the RF output level from the generator when it is connected to the shielded enclosure.

g. TEST Switch and Well: The TEST switch, S102, and well, L103, provides a means of checking system operation. The detector probe is inserted into the well, the pushbutton switch pressed, and the signal level noted on the detector meter.

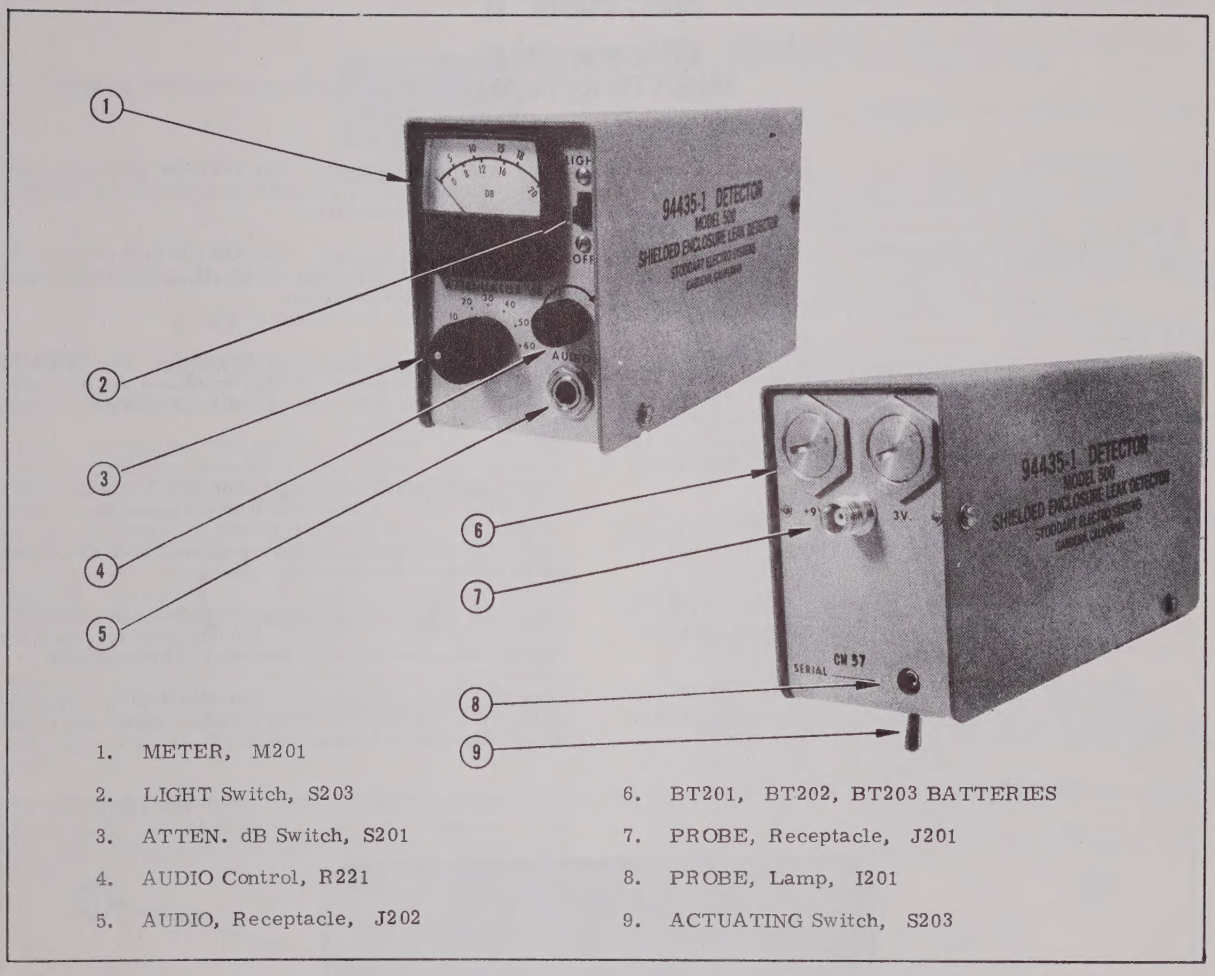
h. 106 kHz OUTPUT Receptacle: The 106 kHz OUTPUT receptacle, J102, is a binding-post terminal for connection of the 40-foot Generator Output Cable.

i. GROUND Receptacle: The GROUND receptacle, J103, is a binding-post terminal for connection of the 5-foot Generator Output Cable.



1. TEST Pushbutton, S102
2. TEST Well
3. 106 kHz OUTPUT Receptacle, J102
4. GROUND Receptacle, J103
5. ON-OFF Switch, S101
6. POWER Indicator, I101
7. OUTPUT Meter, M101
8. 115 V 50/60 Hz Receptacle, J101
9. AC 2 AMP Fuse, F101
10. DC 2 AMP Fuse, F102

Figure 2-1. Generator Operating Controls, Indicators, and Receptacles



1. METER, M201
2. LIGHT Switch, S203
3. ATTEN. dB Switch, S201
4. AUDIO Control, R221
5. AUDIO, Receptacle, J202
6. BT201, BT202, BT203 BATTERIES
7. PROBE, Receptacle, J201
8. PROBE, Lamp, I201
9. ACTUATING Switch, S203

Figure 2-2. Detector Operating Controls, Indicators, and Receptacles

2-5. DETECTOR (Figure 2-2). All operating controls, indicators, and receptacles, are located on the chassis subassembly of the detector. The function of each of these controls, indicators, and receptacles, is as follows:

a. Detector Probe Receptacle: The detector probe receptacle, J201, is located on the front of the chassis subassembly, and provides for connection of the detector probe (or probe extension).

b. +9 V Receptacle: The +9 V receptacle is located on the front of the chassis subassembly, and contains battery BT201 (Refer to paragraph 1-17, "e").

c. 3 V Receptacle: The 3 V receptacle is located on the front of the chassis subassembly, and contains batteries BT202 and BT203 (Refer to paragraph 1-17, "e").

d. ATTENUATOR dB Switch: The ATTENUATOR dB switch, S201, is located on the rear of the chassis subassembly. The switch is a rotary type, having five positions, and inserts up to 60 dB attenuation in 10 dB steps.

f. AUDIO Control: The AUDIO control, R222, is located on the rear of the chassis subassembly. The control adjusts the level of the audio signal from the internal speaker, or headset.

g. AUDIO Receptacle: The AUDIO receptacle, J202, is located on the rear of the chassis subassembly. The receptacle provides for connection of a headset, in which case the internal speaker is automatically silenced.

h. LIGHT Switch: The LIGHT switch, S203, is located on the rear of the chassis subassembly. The switch is a slide type, and applies 3 volts to the probe light, I201, and the meter scale light, I202.

i. Meter: The meter, M201, is located on the rear of the chassis subassembly. The meter indicates a range of 0 to 20 dB above the ATTENUATOR dB setting. An internal light, I202, illuminates the meter scale when the LIGHT switch is actuated.

j. Actuating Switch: The actuating switch S203, is located on the bottom of the chassis subassembly. The switch is a spring-loaded toggle type, and applies

operating voltage (+9 volts) to the detector circuitry when actuated.

2-6. INSTALLATION

2-7. PREPARATION FOR USE. Prepare the equipment for use as described in the following paragraphs.

2-8. UNPACKING. Locate the transit case adjacent to the shielded enclosure to be tested, and proceed as follows:

a. Open the transit case.

b. Remove the AC power cable, and the two generator cables (coiled around the generator).

c. Release the two latching retainers on the hinged aluminum plate.

d. Remove the detector, probe, probe extension, and batteries from the insert.

2-9. DETECTOR ASSEMBLY. Assemble the detector as follows:

a. Remove the covers from the two battery holders (a coin may be used to loosen the covers).

b. Insert the 9-volt battery in the holder.

NOTE

Either one or two batteries will be required, depending on whether 8.4 or 4.2 (or 4.5) volt batteries are used (Refer to Table 1-2).

NOTE

Ensure that correct battery polarity is observed; i.e., on the +9 V holder the "plus" terminal of the battery is inserted first.

c. Insert the two 1.5 volt cells in the 3 V holder.

NOTE

The 3 V battery circuit may be either positive or negative. This circuit operates the lamps, and is not critical to polarization.

d. Connect the probe to the detector probe receptacle on the front of the chassis subassembly.

NOTE

The probe extension may be installed if the additional probe length is required.

2-10. CONNECTION. Connect the generator to the power source and the shielded enclosure to be tested as follows:

a. Connect the power cable (P/N 12644) to the 115 V 50/60 Hz receptacle, J101, on the panel. Connect the other end to the power source.

b. Plug the five foot generator output cable (P/N 94438-1) into the GROUND receptacle, J103, on the panel.

c. Connect the clip end of the five foot cable to a point on the exterior wall of the shielded enclosure, close to a corner. Ensure that a good electrical connection is obtained at this point.

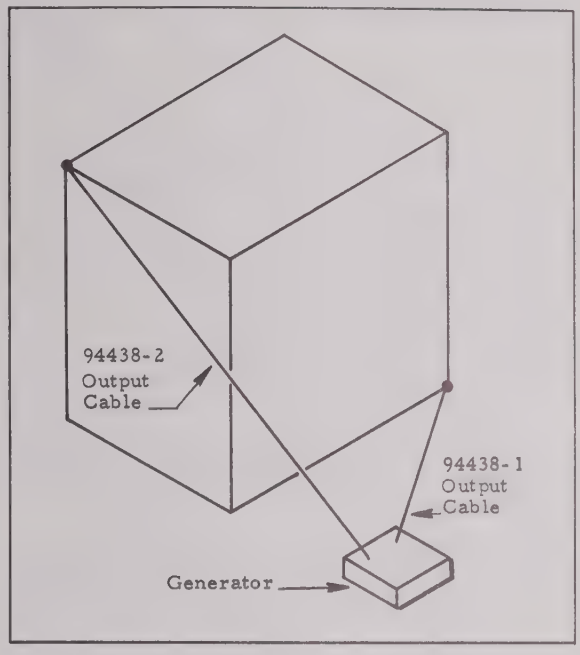


Figure 2-3. Typical Connection to Shielded Enclosure

d. Plug the forty foot generator output cable (P/N 94438-2) into the 106 kHz OUTPUT receptacle, J202, on the panel.

e. Connect the clip end of the forty foot cable to a point on the exterior wall of the shielded enclosure diagonally opposite that of step "c" (Figure 2-3). Ensure that a good electrical connection is obtained at this point.

f. In cases where the forty foot cable is not long enough; i.e., where a larger shielded enclosure is to be tested, additional forty foot output cables may be connected in series, as follows:

1) Fabricate the additional output cable from a forty foot length of flexible #12 insulated wire. A 0.12 microfarad capacitor must be connected in series with the added forty foot length (Figure 2-4). This capacitor must be capable of carrying the output load current (3.9 amperes peak-to-peak for one ampere RMS).

2) A second forty foot cable (and associated capacitor may be fabricated and connected to provide a 120-foot output length if required.

NOTE

The reason for the 0.12 microfarad capacitor in series with each added forty foot length of output cable is to keep the reactance of the combined test circuit reasonably comparable to that of the single forty foot output length. Increasing the total output lead length from 45 (40 +5) feet to 85 (80 +5) feet roughly doubles the X_L in the circuit. Addition of the 0.12 microfarad capacitor in turn doubles the X_C, so the net reactance of the 85-foot circuit tends to equal that of the 45-foot circuit (the actual change in X_L will depend to some extent on how the output cables are physically arranged).

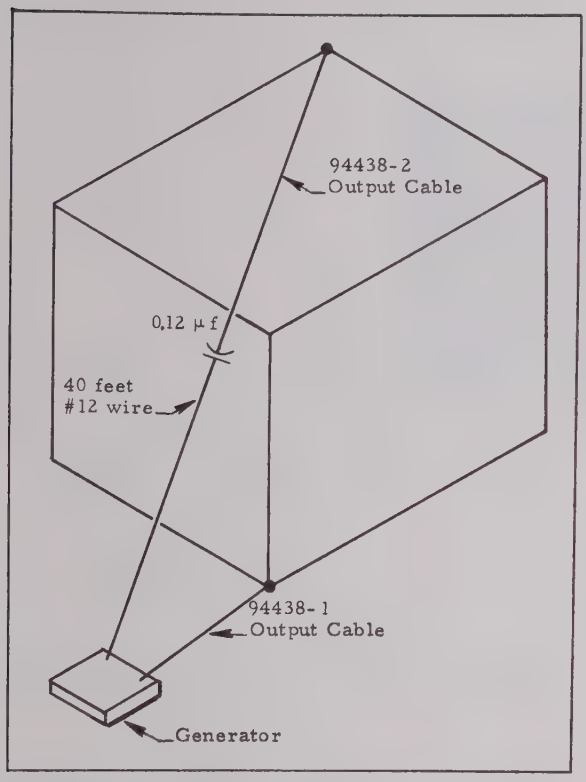


Figure 2-4. Connection With Additional Output Cable

2-11. PRELIMINARY CHECKS

2-12. GENERATOR. Prior to testing, perform the following preliminary checks on the generator:

a. Actuate the generator ON-OFF switch, S101, and check that the POWER indicator, I101, is illuminated.

b. Check that the level indicated on the generator NORMAL OUTPUT 50-70 meter, M101, is within that portion of the meter scale.

NOTE

If the meter does not indicate within the range of 50 to 70 on the scale, recheck the clip connections to the shielded enclosure wall (paragraph 2-10, steps "c" and "e").

2-13. DETECTOR. Prior to testing, perform the following preliminary checks on the detector:

a. Actuate the detector LIGHT switch, S203, and check that the probe light, I201, and meter scale light, I202, are illuminated.

b. Set the detector ATTENUATOR dB switch, S201, to the 60 dB position, and insert the detector probe into the TEST well on the generator panel.

c. Press the detector actuating switch, S204, and the generator TEST switch, S102; check that the detector meter shows an "on-scale" indication.

NOTE

Upon initial checkout after receipt of the equipment, record the meter reading obtained in step "c"; this will then become the reference level for subsequent system checkouts. (15db)

d. Rotate the detector AUDIO control clockwise and check that an approximately 600 Hz tone is audible from the speaker.

2-14. OPERATION

2-15. GENERAL. The shielded enclosure is tested with the generator connected to the exterior wall, as described in paragraph 2-10, and the detector used to probe the interior of the wall. Particular attention should be paid to wall seams, door frames, service lead entries, and other areas where two surfaces join, or are bonded together.

2-16. In cases where a discontinuity exists between two mating surfaces, the magnetic component will "leak" through, and produce an indication on the meter in the detector (and also an audible 600 Hz tone from the speaker or headset).

2-17. Following this procedure, appropriate corrective action should be taken to "tighten up" the shielding, and the test procedure should be repeated to verify that any faults have been rectified.

2-18. OPERATING NOTES. When the generator is connected as shown in Figure 2-3, currents will flow in opposite phase from the two output cables. It is therefore possible that at some point on the exterior wall these currents will cancel each other, producing a "null" line, dividing the structure so that no magnetic field will exist at this point.

2-19. In such a case it would be advisable to connect the generator to two additional diagonally opposing corners and repeat the tests, then repeat again at a third set of opposing corners to ensure that all walls have been adequately excited.

NOTE

The above conditions will not be found in all shielded enclosure installations, or may vary in intensity and/or location of the "null" in a particular installation. It is therefore advisable that the user become familiar with the operation of the detector system by making a series of tests on the enclosure from various connection points (if practical) to determine if the particular installation can be satisfactorily checked from a single set of corners.

2-20. An additional condition should also be taken into account when conducting an examination of the shielded enclosure; i.e., that the RF current will be strongest (and therefore any magnetic field setup by a discontinuity) closer to the actual connection points of the output cables.

SECTION III
PRINCIPLES OF OPERATION

3-1. GENERAL

3-2. This section covers the principles of operation of the STODDART Model 500 Shielded Enclosure Leak Detection System. The section is divided into a functional discussion, and a circuit analysis of the equipment.

3-3. FUNCTIONAL DISCUSSION

3-4. The functional discussion that follows is based on the System Block Diagram, Figure 3-1.

3-5. SYSTEM OPERATION. The generator is connected to opposing exterior corners of the shielded enclosure, and induces an RF current to flow throughout the entire outer surface of the enclosure. The frequency employed, 106 kHz, is low enough to ensure a substantially uniform RF field is obtained on all six sides of the enclosure as compared to a much higher frequency that would set up standing waves on the surface.

NOTE

Actually, the field will be stronger in the vicinity of each corner where the test leads are connected.

3-6. A discontinuity in the shielding effectiveness of the enclosure, caused by a "dirty" seam, or other form of minute opening or separation between panels, then permits the signal to penetrate into the interior of the enclosure as a relatively strong magnetic field. This magnetic field is vertical to the current flow, causing the penetration at the discontinuity.

3-7. This 106 kHz magnetic field induces a signal voltage in the detector probe. The signal is amplified and demodulated, to produce both an indication on an output meter, and an aural (approximately 600 Hz) tone through the internal speaker (or headset). The detector unit incorporates a step attenuator, which permits the "reading" to be maintained "on-scale" while the meter reading in dB permits relative measurements to be obtained as the discontinuity is corrected.

3-8. GENERATOR SECTION. The generator section consists of five basic circuits; i.e., the oscillator, constant current loop, modulator, output circuit, and the power supply.

a. Oscillator: The oscillator is self-excited at a frequency of 106 kHz, with the output applied to one input of a variable gain amplifier in the constant current loop.

b. Constant Current Loop: The constant current loop consists of the current sampling circuit, the variable gain amplifier, and the reference circuit. The variable gain amplifier functions to automatically limit the drive applied to the output stages to maintain a constant one ampere current flow in the load (shielded enclosure). This is accomplished by sampling the output current, and then applying this to one input of the variable gain amplifier (the 106 kHz oscillator output is applied as the other input). Thus, an increase

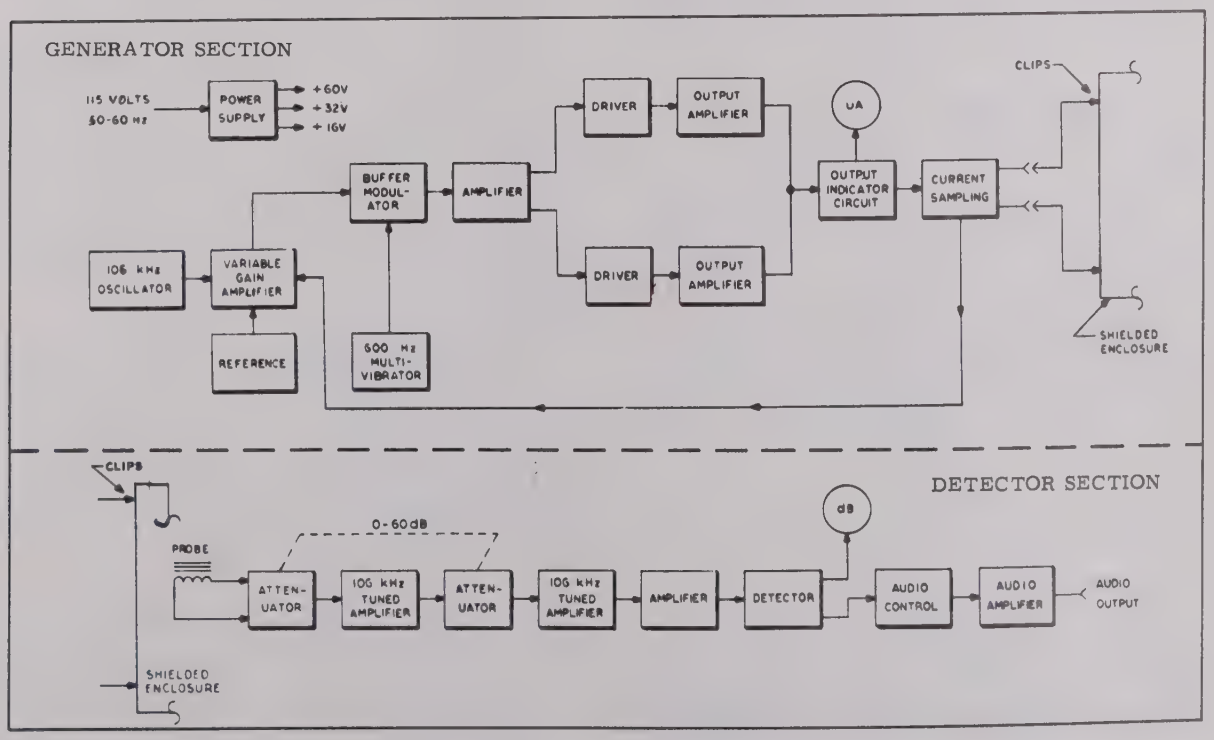


Figure 3-1. Functional Block Diagram, Model 500 Shielded Enclosure Leak Detection System

in output current will decrease the amplifier gain (and vice versa), in turn, lowering the drive applied to the output amplifiers.

c. Modulator: The modulator consists of a free-running 600 Hz multivibrator, and a buffer/modulator stage. The multivibrator output effectively "chops" the 106 kHz signal from the variable gain amplifier at a 600 Hz rate, producing a pulse modulation output from the buffer/modulator. This is at a 50-percent duty cycle, and the buffer/modulator output is applied to the output stage.

d. Output Circuit: The pulse modulated signal is amplified, and applied to a complementary symmetrical output circuit, consisting of a driver and output amplifier in each leg. The output from this final stage is then applied through a metering circuit, and the current sampling circuit to the output receptacle, where it is connected to the shielded enclosure.

e. Power Supply: The power supply operates from the 115 volt, 50 to 60 Hz AC power source, and produces outputs of +60, +32, and +16 volts, respectively. These are then applied as operating voltages to the individual stages of the generator.

3-9. DETECTOR SECTION. The detector section consists of five basic circuits; i.e., the input circuits, attenuator, amplifying circuits, meter detector, and audio detector and amplifier.

a. Input Circuits: The input circuits consist of the probe, and an input operational amplifier. The magnetic component generated by the 106 kHz RF current at a discontinuity in the shielding of the enclosure induces a voltage in the probe. This voltage is then amplified by the input operational amplifier, and applied to the attenuator.

b. Attenuator: The variable attenuator provides for insertion of up to 60 dB of attenuation to the signal in 10 dB steps. This permits the meter reading to be maintained "on-scale" in areas of high level signal penetration, thus a comparison may be obtained while "tightening up" the shielded enclosure.

c. Amplifying Circuits: The signal from the attenuator is then amplified by two additional operational amplifiers, and the output is applied to the audio and meter detectors.

d. Meter Detector: The meter detector demodulates the 106 kHz signal to recover a DC level, which in turn is displayed on the meter. The meter is calibrated from 0 to 20 dB.

e. Audio Detector and Amplifier: The audio detector demodulates the 106 kHz signal to recover the 600 Hz component. This aural tone is then amplified and applied to the internal speaker. A headset receptacle is also provided, and automatically silences the speaker when the headset is connected.

3-10. CIRCUIT ANALYSIS

3-11. The circuit analysis that follows is based on the Schematic Diagram, Figure 3-2.

3-12. GENERATOR

3-13. 106 kHz OSCILLATOR. Transistor Q101 functions as a self-excited 106 kHz oscillator, with the tuned circuit consisting of L101, C101, and C102. The emitter output is then applied across potentiometer R107, and through C103 to the base of Q102 in the variable gain amplifier stage. The potentiometer is an internal factory set adjustment to provide the correct drive level to the following stages.

3-14. VARIABLE GAIN AMPLIFIER. Transistor Q102 functions as a variable gain amplifier, with the gain controlled by emitter follower Q103 in the constant current loop, and resonated to 106 kHz by L102 and C105 in the collector circuit. An increase in the output current through the primary of the current sampling transformer, T101, produces a positive going output from diode CR108.

3-15. The positive rectified output from CR108 is filtered by C106 and R113 (in parallel with the input resistance of Q103). This positive DC level is applied to the base of Q103, increasing the current conduction through Q103 and R110, causing the emitter level to rise. As the emitter of Q102 is also tied to this point, this is the same as applying a negative bias to the base of Q102. This reduces the gain of Q102 until the output current in the primary of T101 returns to almost the previous level. The output from Q102 is then applied through C107 to the base of Q104, the buffer/modulator. Potentiometer R114 adjusts the bias of Q103, permitting the desired current level to be established, while diodes CR101 and CR102 provide a reference for the control stage.

3-16. The time constant of the RC filter (C106 shunted by the effective resistance of R114 in parallel with the input resistance of Q103) is much longer than the reciprocal time of the 600 Hz modulation rate.

3-17. MODULATING CIRCUIT. Transistors Q105 and Q106 function as a free-running multivibrator. The repetition rate, established by C108 and R120, and C109 and R121, is approximately 600 Hz. The collector output from Q106 is applied through C110 and R116 to the base of emitter follower Q104, where it "chops" the 106 kHz input from Q102 to produce a pulse modulated signal having approximately a 50-percent duty cycle across R118. The emitter output from Q104 is then applied through R123 and C111 to the base of Q107, and through R139 to the test loop, L103. The signal in the test loop permits the detector unit to be checked for proper operation.

3-18. OUTPUT AMPLIFIERS. The pulse modulated 106 kHz signal is amplified by Q107 and applied to the complementary symmetrical drivers and output amplifiers. The signal at the collector of Q107 is directly coupled to the base of driver Q109, and also through R127 and diodes CR103 thru CR105 to the base of driver Q108. Both drivers, in turn, are directly coupled to the base of their respective output amplifiers, Q110 and Q111, with the output taken at the emitter junction of Q110 and Q111. Zener diode CR106 functions to limit the initial current when the generator is turned on, or to limit the output current if a direct short circuit is accidently applied across the output terminals, J102 and J103.

3-19. OUTPUT CIRCUIT. The output signal from Q110 and Q111 is applied through C114, R134, and the primary of T101, to the 106 kHz OUTPUT binding post, J102. The voltage drop across R134 in turn is rectified by diode CR107, filtered by C115 and the meter resistance in series with R135, to provide visual monitoring of the output level on meter M101. The signal through the primary of T101 provides the control level for the variable gain amplifier (paragraphs 3-14 thru 3-16).

3-20. The complete output circuit from Q110 and Q111; i.e., through the generator output cable from J102, shielded enclosure, and back to J103, forms a series resonant circuit at 106 kHz when the combined inductive reactance in the circuit equals the capacitive reactance of C114. This occurs with an inductance of approximately 19 microhenries at 106 kHz. Measurements made with 5 and 40 foot output cables connected to a typical shielded enclosure show that inductive

loads equivalent to approximately 10 to 30 microhenries may be encountered, with a typical average value of 15 microhenries.

3-21. The control range of the output circuit will hold the 106 kHz output current constant (within several dB) for effective load inductance changes from approximately 5 to 50 microhenries.

NOTE

In cases where additional output cable length is required, additional capacitive reactance must also be added to compensate (Refer to paragraph 2-10).

3-22. POWER SUPPLY. The 115 volt, 50 to 60 Hz, power input is applied through switch S101 across the primary winding of the power transformer, T102. The input power is fused at two amperes by F101. The secondary winding of T102 is applied across a full-wave bridge rectifier, CR109, and the +60 volt output is filtered by C116. This output is fused at two amperes by F102, and applied to the +60 volt bus. A voltage divider network, R136 thru R138, is also connected across the +60 volt output, and provides additional operating voltages of +32 and +16 volts. The +32 volt output is filtered by C117, while the +16 volt output is filtered by C118.

3-23. DETECTOR

3-24. INPUT CIRCUIT. The detector probe, L201, is connected via receptacle J201 to the input circuit. The probe is a ferrite core and coil resonated at 106 kHz by C201 and C202.

3-25. ATTENUATOR NETWORK. From the junction of C201 and C202 the signal enters the A and B sections of the Attenuator switch S201 where its level may be adjusted before passing thru C203 to the first amplifier. Attenuation is also afforded by S201C before the amplified signal enters AR202.

3-26. AMPLIFYING CIRCUITS. Amplifiers AR201 and AR202 afford stable gain as well as selectivity at very low cost in battery current consumption.

3-27. POWER DETECTOR. Q201 and Q202 combines an Amplifier and Power Detector, Q202 is biased critically at a point just below conduction. This bias is stabilized by CR202. Incoming signals cause Q202 to conduct with a resultant up swing in M201 meter and audio content at Q202 emitter.

3-28. AUDIO AMPLIFIER. Audio content is filtered by C211, C212 and R219 and appears at the Audio Control R221. Audio at the arm of R221 is again filtered by R222 and C216 before entering AR203. AR203 furnishes the necessary power gain to drive the speaker SP201 or headphones thru J202.

SECTION IV
MAINTENANCE

4-1. INTRODUCTION

4-2. The maintenance information presented in this section is intended for use only by skilled personnel, experienced in the use of laboratory test equipment.

4-3. TROUBLESHOOTING

4-4. GENERAL. Troubleshooting of the Model 500 Shielded Enclosure Leak Detection System is simplified by use of the Schematic Diagram, Figure 3-2, and reference to the Principles of Operation presented in Section III.

4-5. PROCEDURE. A malfunction within the equipment can usually be localized to a particular circuit by functional means. Conventional voltage/resistance type measurements should then suffice to locate any source of trouble within the particular circuit, once the malfunction has been localized. The voltage/resistance measurements may be verified for any suspected component in a particular circuit by reference to the Schematic Diagram.

4-6. TEST EQUIPMENT REQUIRED FOR MAINTENANCE. The test equipment required for troubleshooting, alignment, and/or calibration, is tabulated in Table 4-1.

4-7. CORRECTIVE MAINTENANCE

4-8. COMPONENT LOCATION. Location of the components within the generator is illustrated on Figures 4-1 and 4-2. Location of the components within the detector is illustrated on Figures 4-3 and 4-4.

4-9. ADJUSTMENT. Adjust the generator as follows:

a. Connect the test equipment as shown in Figure 4-5.

b. Remove the DC 2 AMP fuse, F102.

c. Set potentiometers R107 and R114 at approximate mid-range points.

d. Adjust the variable inductor (Table 4-1) to 19 microhenries.

e. Set the POWER switch, S101, to the ON position and allow approximately 30 minutes warmup time.

f. Check the DC output voltages from the power supply.

NOTE

Check the +60 volts at the DC 2 AMP fuseholder, the +32 volts at the collector of Q103, and the +16 volts at the collector of Q104.

g. Connect the oscilloscope probe to the junction of C101 and C102; check that the output waveform is approximately 8 volts, peak-to-peak.

h. Connect the frequency counter to the junction of R105 and R107; adjust the slug in L101 to obtain an output frequency of 106 kHz.

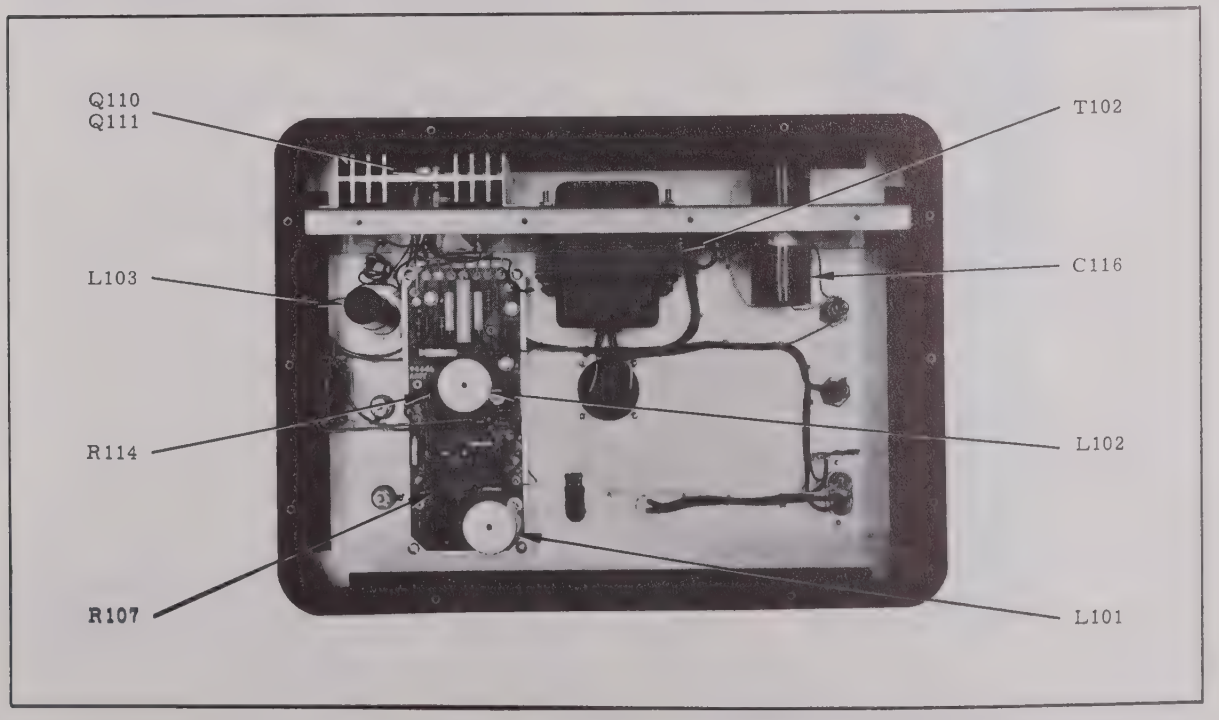


Figure 4-1. Component Location, Generator Chassis

Table 4-1. Test Equipment Required for Maintenance

ITEM	RECOMMENDED TYPE	USE
Variable Inductor	General Radio, Model 107-3	Dummy load
DC VTVM	Hewlett-Packard, Model 410B	Transistor DC voltage measurements
Oscilloscope	Tektronix, Type 515	Waveform observations
Frequency Counter	Hewlett-Packard, Model 523-C	Frequency measurement
AC VTVM	Hewlett-Packard, Model 400H	Output measurement
RF Current Probe	STODDART, Model 91550-1	Output measurement
50-ohm Termination	STODDART, Model 90552	Used with 91550-1 current probe

NOTE

No adjustments are required for the detector.

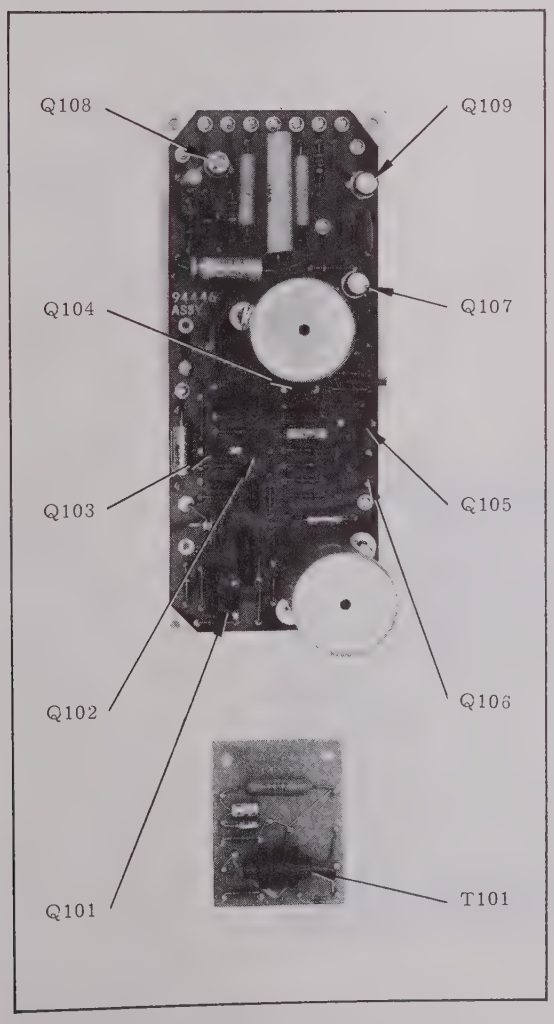


Figure 4-2. Component Location, Generator P.C. Boards

i. Connect the oscilloscope to the emitter of Q104; adjust the slug in L102 for maximum output.

j. Replace the DC 2 AMP fuse, F102.

k. Observe the current probe output (Figure 4-5) and adjust R114 until the output waveform on the oscilloscope is 3.9 volts, average peak-to-peak (as illustrated in Figure A). Check that the meter, M101, indicates 60 ±5.

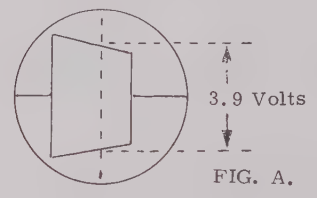


FIG. A.

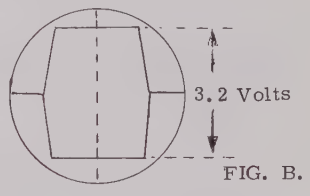


FIG. B.

1. Set the variable inductor to 50 microhenries and observe that the output waveform is over 3 volts, peak-to-peak(as illustrated in Figure B). The panel meter, M101, should not drop more than 10 points from the original setting.

m. Sweep the variable inductor from 8 to 50 microhenries; observe that the AC VTVM reads 0.65 volts ±10%.

4-10. COMPONENT REPLACEMENT

4-11. GENERAL PRECAUTIONS. Observe the following general precautions while troubleshooting, or replacing components within the individual units of the system.

a. Use extreme care in unsoldering solid-state components, small capacitors, or resistors.

b. Do not use a soldering iron rated at more than 37 watts. Do not apply heat to the connection for more than a few seconds at a time.

c. Do not excessively bend or twist leads of transistors, diodes, or small capacitors and resistors; they break easily.

4-12. PRINTED CIRCUIT BOARDS. Printed circuit boards consist of an insulating base (lamination), conductors (foil), feedthrough couplings, and components. The lamination is the structural part of the circuit board, and supports and positions the components. As most laminations are thin, 1/16 inch or less, they are very fragile and must be handled with care.

4-13. The first step in servicing a printed circuit board is to examine the board carefully with a strong

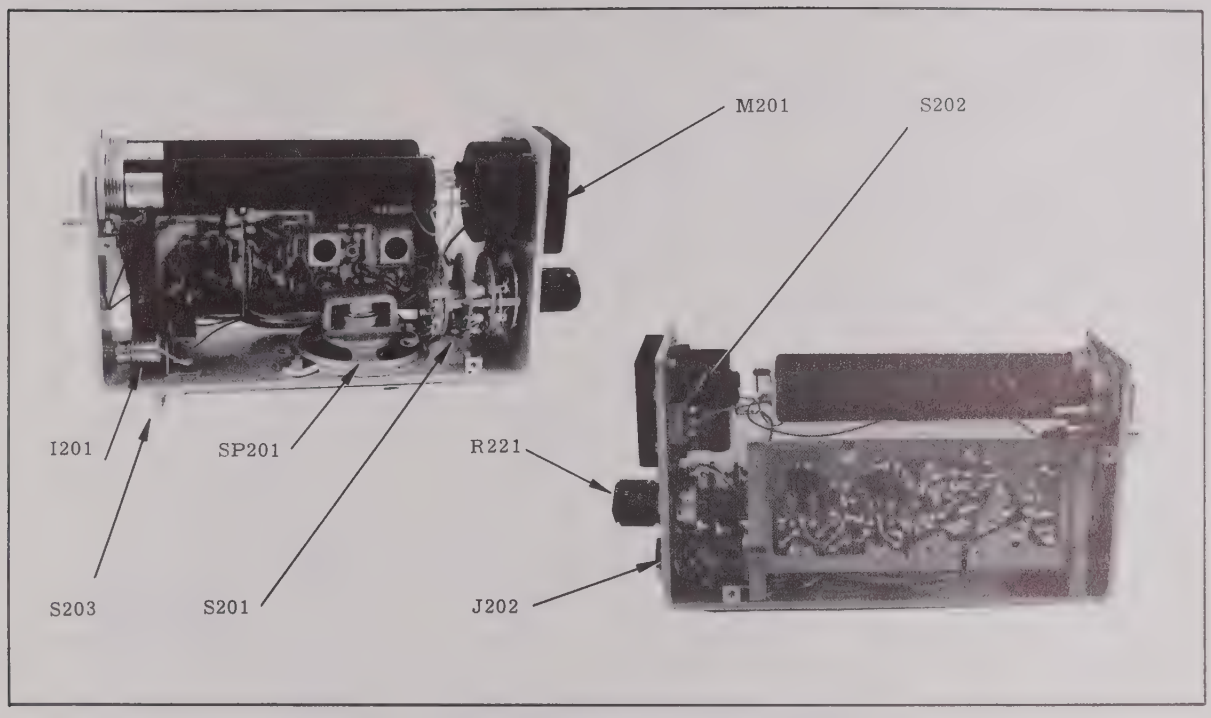


Figure 4-3. Component Location, Detector Chassis

magnifying glass. Such an examination may reveal physical damage to the lamination, foil, components, or leads.

4-14. Should examination reveal a broken foil, it is usually more practical to repair the foil than to replace the entire circuit board. If the break is large, place a short length of copper wire across the break and solder the ends to the broken foil. If the break is small, try flowing solder across the break. Do not apply excessive heat, or allow solder to flow to other parts of the foil.

4-15. REMOVAL OF WIRES OR COMPONENTS. When removing wires or components from a printed circuit board, observe the following precautions:

a. Use a soldering aid for manipulating wires.

b. Use heatsinks to protect nearby parts.

c. Heat connections only until wires loosen.

d. Remove wires quickly (but carefully).

e. Remove excess solder before it hardens.

4-16. INSTALLATION OR MOUNTING OF COMPONENTS. When installing or mounting components on a printed circuit board, observe the following precautions:

a. Inspect the board to verify that it is clean and dry.

b. Install heatsinks to protect components.

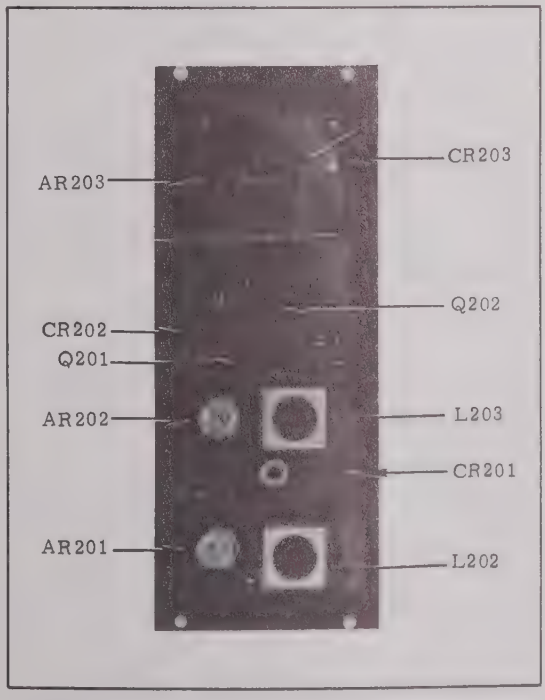


Figure 4-4. Component Location, Detector P.C. Board

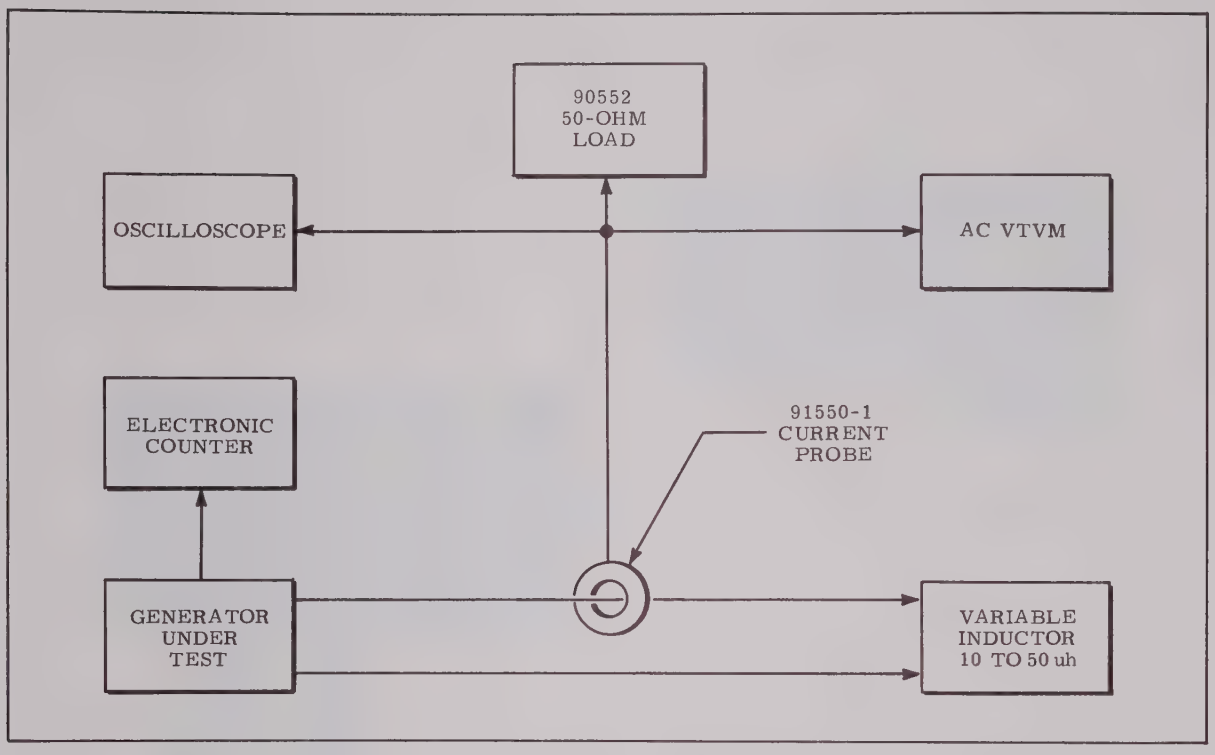


Figure 4-5. Test Setup

c. Trim component leads to the approximate length required.

d. Place the components in the correct mounting position.

e. Insert the component leads through the mounting holes in the board (or wrap the leads around mounting terminals.

f. Solder the leads in place. Use sufficient heat to assure a good soldering joint, but be careful to avoid excessive heat.

g. Trim the leads close to the solder joint on the other side of the board.

h. Clean excess solder and resin from all connections.

i. Remove heatsinks.

4-17. TRANSISTOR TESTING. If it is suspected that a particular transistor is defective, either check the transistor in a commercial transistor tester, or replace it with one of known quality.

4-18. If neither a transistor tester nor replacement transistor is available, the suspected transistor may be given a simple test with an ohmmeter, as follows:

CAUTION

THE OHMMETER MUST NOT HAVE A HIGHER POTENTIAL THAN 4.5 VOLTS DC, OR DAMAGE MAY OCCUR.

a. In checking a transistor with an ohmmeter, the transistor is treated as two separate semiconductor diodes having a common junction. In a good transistor, the diodes will have different forward and inverse resistances, depending upon the polarity of the DC voltage applied by the ohmmeter. When the anode of the diode is made positive with respect to the cathode, the forward resistance should be low. Conversely, when the anode is made negative with respect to the cathode, the inverse resistance should be high.

b. The greater the ratio of the inverse resistance to the forward resistance, the better the transistor. This ratio should be at least 10:1 or greater, in high quality, low-leakage transistors. A transistor is defective, and must be replaced if the forward resistance of either diode is high, if the inverse resistance of either diode is low, or if the ratio of the inverse resistance to the forward resistance is significantly lower than 10:1.

94443-1
GENERATOR

SYMBOL	DESCRIPTION
C101	CAPACITOR, FIXED, MICA: 2200 pf; ±2%; 500 VDCW Elmenco type DM19F222G STODDART No. 11655-222
C102	CAPACITOR, FIXED, MICA: 4700 pf; ±2%; 500 VDCW Elmenco type DM19F472G STODDART No. 11655-472
C103	CAPACITOR, FIXED, MICA: 200 pf; ±10%; 500 VDCW Elmenco type DM19F210K STODDART No. 11790-201
C104	CAPACITOR, FIXED, CERAMIC: 0.1 mfd; ±20%; 12 VDCW Erie type 5635-000-Y5F0-104M STODDART No. 12647
C105	CAPACITOR, FIXED, MICA: 1200 pf; ±2%; 500 VDCW Elmenco type DM19F122G STODDART No. 11655-122
C106	CAPACITOR, FIXED, ELECTROLYTIC: 47 mfd; ±10%; 20 VDCW Sprague type 150D476X9020R2 STODDART No. 11555
C107	CAPACITOR, FIXED, MICA: 330 pf; ±10%; 500 VDCW Elmenco type DM15F331K STODDART No. 11790-331
C108	CAPACITOR, FIXED, CERAMIC: 0.02 mfd; 150 VDCW Centralab type DDM-203 STODDART No. 11474
C109	Same as C108
C110	CAPACITOR, FIXED, FILM: 0.22 mfd; ±10%; 100 VDCW IMB Electronic Products Co. , type XA2C224K STODDART No. 12581-224
C111	CAPACITOR, FIXED, CERAMIC: 0.001 mfd; ±20%; 1000 VDCW Sprague type 5GA-D10 STODDART No. 18414
C112	CAPACITOR, FIXED, ELECTROLYTIC: 10 mfd; 150 VDCW Sprague type TE-1507 STODDART No. 12648
C113	CAPACITOR, FIXED, CERAMIC: 1 mfd; 3 VDCW Sprague type HY-135 STODDART No. 12649
C114	CAPACITOR, FIXED, PLASTIC: 0.12 mfd; 200 VDCW IMB Electronic Products Co., type MA2G124K STODDART No. 12726
C115	CAPACITOR, FIXED, ELECTROLYTIC: 1 mfd; ±20%; 35 VDCW Sprague type 150D105X0035A2 STODDART No. 11782

SYMBOL	DESCRIPTION
C116	CAPACITOR, FIXED, ELECTROLYTIC: 2500 mfd; +50 to -10%; 75 VDCW Sprague type 36D252F075AC0A STODDART No. 12609
C117	CAPACITOR, FIXED, ELECTROLYTIC: 100 mfd; 50 VDCW Sprague type 39D107G050EJ4 STODDART No. 12727
C118	CAPACITOR, FIXED, ELECTROLYTIC: 10 mfd; ±10%; 200 VDCW Sprague type 150D106X9020B2 STODDART No. 11722
C119	CAPACITOR, FIXED, CERAMIC: 0.005 mfd; ±20%; 50 VDCW Sprague type 55C33 STODDART No. 12737
CR101	SEMICONDUCTOR DEVICE, DIODE: 1N754
CR102	Same as CR101
CR103	SEMICONDUCTOR DEVICE, DIODE: 1N3754
CR104	Same as CR103
CR105	Same as CR103
CR106	Same as CR101
CR107	Same as CR103
CR108	SEMICONDUCTOR DEVICE, DIODE: 1N251
CR109	SEMICONDUCTOR DEVICE, DIODE: 100 PIV; 2 amp silicon rectifier bridge; VARO type VS148 STODDART No. 12610
F101	FUSE, CARTRIDGE: 2 amp Littlefuse type 3AG-2A STODDART No. 12278
F102	Same as F101
I101	LAMP ASSY; Neon; 1/3 watt; red lens; 1/2" dia; 6" leads; Leecraft type 32-2311 STODDART No. 12611
J101	CONNECTOR, RECEPTACLE: Power receptacle; Switchcraft type AC3G STODDART No. 12734
J102	CONNECTOR, RECEPTACLE: Banana plug type; red binding post; H.H. Smith type 459 STODDART No. 12733-2
J103	CONNECTOR, RECEPTACLE: Banana plug type; black binding post; H.H. Smith type 459 STODDART No. 12733-1
L101	INDUCTOR, RF: 1.4 to 2.0 microhenries J.W. Miller type 4414 STODDART No. 12646

SYMBOL	DESCRIPTION
L102	Same as L101
L103	INDUCTOR, RF: Test loop (listed for reference only)
M101	METER: 200 ma; 500 ohms; scale 0-10; AMMO Instrument type AM-1 STODDART No. 12730
Q101	TRANSISTOR: 2N3707
Q102	Same as Q101
Q103	Same as Q101
Q104	Same as Q101
Q105	Same as Q101
Q106	Same as Q101
Q107	TRANSISTOR: MM3005
Q108	Same as Q107
Q109	TRANSISTOR: MM4005
Q110	TRANSISTOR: SJ3507
Q111	TRANSISTOR: MJ2802
R101	RESISTOR, FIXED, COMPOSITION: 33,000 ohms; ±5%; 1/4 watt MIL type RC07GF333J STODDART No. 11693-333
R102	RESISTOR, FIXED, COMPOSITION: 10,000 ohms; ±5%; 1/4 watt MIL type RC07GF103J STODDART No. 11693-103
R103	RESISTOR, FIXED, COMPOSITION: 4700 ohms; ±5%; 1/4 watt MIL type RC07GF472J STODDART No. 11693-472
R104	RESISTOR, FIXED, COMPOSITION: 3300 ohms; ±5%; 1/4 watt MIL type RC07GF332J STODDART No. 11693-332
R105	RESISTOR, FIXED, COMPOSITION: 39,000 ohms; ±5%; 1/4 watt MIL type RC07GF393J STODDART No. 11693-393
R106	Not used
R107	RESISTOR, VARIABLE, COMPOSITION: 10,000 ohms; 1/4 watt CTS type X201-R103B STODDART No. 12728
R108	RESISTOR, FIXED, COMPOSITION: 22,000 ohms; ±5%; 1/4 watt MIL type RC07GF223J STODDART No. 11693-223

SYMBOL	DESCRIPTION
R109	RESISTOR, FIXED, COMPOSITION: 2200 ohms; ±5%; 1/4 watt MIL type RC07GF222J STODDART No. 11693-222
R110	RESISTOR, FIXED, COMPOSITION: 1000 ohms; ±5%; 1/4 watt MIL type RC07GF102J STODDART No. 11693-102
R111	Same as R102
R112	RESISTOR, FIXED, COMPOSITION: 6200 ohms; ±5%; 1/4 watt MIL type RC07GF622J STODDART No. 11693-622
R113	RESISTOR, FIXED, COMPOSITION: 15,000 ohms; ±5%; 1/4 watt MIL type RC07GF153J STODDART No. 11693-153
R114	RESISTOR, VARIABLE, COMPOSITION: 5000 ohms; 1/4 watt CTS type X201-R502B STODDART No. 12729
R115	RESISTOR, FIXED, COMPOSITION: 6800 ohms; ±5%; 1/4 watt MIL type RC07GF682J STODDART No. 11693-682
R116	RESISTOR, FIXED, COMPOSITION: 12,000 ohms; ±5%; 1/4 watt MIL type RC07GF123J STODDART No. 11693-123
R117	Same as R116
R118	Same as R104
R119	RESISTOR, FIXED, COMPOSITION: 1800 ohms; ±5%; 1/4 watt MIL type RC07GF182J
R120	RESISTOR, FIXED, COMPOSITION: 56,000 ohms; ±5%; 1/4 watt MIL type RC07GF563J STODDART No. 11693-563
R121	Same as R120
R122	Same as R119
R123	Same as R103
R124	Same as R103
R125	RESISTOR, FIXED, COMPOSITION: 270 ohms; ±5%; 1/4 watt MIL type RC07GF271J STODDART No. 11693-271
R126	RESISTOR, FIXED, COMPOSITION: 91,000 ohms; ±5%; 1/4 watt MIL type RC07GF913J STODDART No. 11693-913
R127	RESISTOR, FIXED, COMPOSITION: 150 ohms; ±5%; 1/4 watt MIL type RC07GF151J STODDART No. 11693-151

SYMBOL	DESCRIPTION
R128	RESISTOR, FIXED, COMPOSITION: 4700 ohms; ±5%; 1/2 watt MIL type RC20GF472J STODDART No. 10011-472
R129	RESISTOR, FIXED, COMPOSITION: 2200 ohms; ±5%; 1/2 watt MIL type RC20GF222J STODDART No. 10011-222
R130	RESISTOR, FIXED, COMPOSITION: 470 ohms; ±5%; 1/2 watt MIL type RC20GF471J STODDART No. 10011-471
R131	Same as R130
R132	RESISTOR, FIXED, WIREWOUND: 1.0 ohm; ±5%; 5 watts Ohmite type 7/8C-54-F-1OHM STODDART No. 18081-1R0
R133	Same as R132
R134	RESISTOR, FIXED, WIREWOUND: 2.0 ohms; ±5%; 5 watts Ohmite type 7/8C-54-F-2OHM STODDART No. 18081-2R0
R135	Same as R113
R136	RESISTOR, FIXED, COMPOSITION: 1200 ohms; ±5%; 2 watts MIL type RC42GF122J STODDART No. 10377-122
R137	RESISTOR, FIXED, COMPOSITION: 1000 ohms; ±5%; 1/2 watt MIL type RC20GF102J STODDART No. 10011-102

SYMBOL	DESCRIPTION
R138	RESISTOR, FIXED, COMPOSITION: 3900 ohms; ±5%; 1/2 watt MIL type RC20GF392J STODDART No. 10011-392
R139	Same as R103
R140	Same as R112
S101	SWITCH, TOGGLE: SPST; Arrow Hart and Hegeman; type 20994-10NV STODDART No. 12159
S102	SWITCH, PUSHBUTTON: SPST; momentary contact type Cutler and Hammer type 8411K8 STODDART No. 12607
T101	TRANSFORMER, RF: 50 millihenry ferrite core STODDART No. 12645
T102	TRANSFORMER, POWER: 115 V; 60 Hz; primary winding; 45 V; 2 amp; secondary winding STODDART No. 12612
W101	CABLE ASSY: Electrical power Belden Wire type 17258 STODDART No. 12644

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DETECTOR

SYMBOL	DESCRIPTION
AR201	INTEGRATED CIRCUIT: RCA type CA-3021 STODDART No. 12755
AR202	Same as AR201
AR203	INTEGRATED CIRCUIT: GE type PA-234 STODDART No. 12756
BT201	BATTERY: Nominal 8 volts (Refer to Table 1-2)
BT202	BATTERY: Nominal 1.5 volts (Refer to Table 1-2)
BT203	Same as BT202
C201	CAPACITOR, FIXED, MICA: 6200 pf; ±1% 500 vdcw Arco-Elmenco type DM30 STODDART No. 12753-622
C202	CAPACITOR, FIXED, FILM 0.01 mf; ±5%, 80 vdcw Sprague No. 192P1035R8 STODDART No. 12293-103
C203	CAPACITOR, FIXED, CERAMIC: 0.02 mf, 25 vdcw Erie No. 5835-000-Y5U0-208Z STODDART No. 12650
C204	CAPACITOR, FIXED, MICA: 470 pf; ±5%; 500 vdcw Arco Electronics type DM15F471J STODDART No. 11308-471
C205	CAPACITOR, FIXED, ELECTRO- 10 mf; Kemet type K-10-W-10 LYTIC: STODDART No. 12559
C206	Same as C203
C207	Same as C204
C208	Same as C205
C209	Same as C203
C210	Same as C203
C211	Same as C203
C212	Same as C203

SYMBOL	DESCRIPTION
C213	Same as C205
C214	Same as C205
C215	Same as C205
C216	Same as C203
C217	Same as C205
C218	Same as C205
CR201	SEMICONDUCTOR DEVICE, DIODE: 1N4735A; 6.2 volt Zener Fairchild type 1N4735A STODDART No. 1N4735A
CR202	SEMICONDUCTOR DEVICE, DIODE: 1N4154, Silicon Fairchild type 1N4154 STODDART No. 1N4154
CR203	SEMICONDUCTOR DEVICE, DIODE: 1N498, Germanium Fairchild type 1N498 STODDART No. 1N498
I201	LAMP, INCANDESCENT: GE type 222 STODDART No. 12551
I202	LAMP, INCANDESCENT: Kemtron type X-400C STODDART No. 12539
J201	CONNECTOR, RECEPTACLE: TNC type panel mount Kings Electronics type KA-71-02 STODDART No. 12643
J202	CONNECTOR, RECEPTACLE: Telephone jack Switchcraft type 12-A STODDART No. 12550
L201	COIL ASSEMBLY; Sensor coil STODDART No. 12549
L202	INDUCTOR, RF; 3 to 10 mhy J. W. Miller type 9060 STODDART No. 12757
L203	Same as L202

SYMBOL	DESCRIPTION
M201	METER; 0 to 20 dB scale STODDART No. 12548
Q201	TRANSISTOR; 2N3565 Fairchild type 2N3565 STODDART No. 2N3565
Q202	Same as Q201
R201	RESISTOR, FIXED, COMPOSITION; 680 ohms, ±5%, 1/4 watt MIL type RC076F681J STODDART No. 11693-681
R202	RESISTOR, FIXED, COMPOSITION; 330 ohms; ±5%, 1/4 watt MIL type RC07GF331J STODDART No. 11693-331
R203	RESISTOR, FIXED, COMPOSITION; 82 ohms; ±5%, 1/4 watt MIL type RC07GF820J STODDART No. 11693-820
R204	RESISTOR, FIXED, COMPOSITION; 22 ohms; ±5%, 1/4 watt MIL type RC076F220J STODDART No. 11693-220
R205	RESISTOR, FIXED, COMPOSITION; 10 ohms; ±5%; 1/4 watt MIL type RC07GF100J STODDART No. 11693-100
R206	Same as R201
R207	RESISTOR, FIXED, COMPOSITION; 1000 ohms; ±5%; 1/4 watt MIL type RC07GF102J STODDART No. 11693-102
R208	RESISTOR, FIXED, COMPOSITION; 750 ohms; ±5%; 1/4 watt MIL type RC07GF751J STODDART No. 11693-751
R209	RESISTOR, FIXED, COMPOSITION; 200 ohms; ±5%; 1/4 watt MIL type RC07GF201J STODDART No. 11693-201
R210	RESISTOR, FIXED, COMPOSITION; 68 ohms; ±5%; 1/4 watt MIL type RC07GF680J STODDART No. 11693-680
R211	RESISTOR, VARIABLE, WIREWOUND; 5000 ohms Beckman type 62 P STODDART No. 18546-502
R212	Same as R201

SYMBOL	DESCRIPTION
R213	RESISTOR, FIXED, COMPOSITION; 82,000 ohms; ±5%; 1/4 watt MIL type RC07GF823J STODDART No. 11693-823
R214	RESISTOR, FIXED, COMPOSITION; 33,000 ohms; ±5%; 1/4 watt MIL type RC07GF333J STODDART No. 11693-333
R215	Same as R202
R216	RESISTOR, FIXED, COMPOSITION; 3900 ohms; ±5%; 1/4 watt MIL type RC07GF392J STODDART No. 11693-392
R217	Same as R214
R218	Same as R214
R219	RESISTOR, FIXED, COMPOSITION; 1500 ohms; ±5%; 1/4 watt MIL type RC07GF152J STODDART No. 11693-152
R220	RESISTOR, FIXED, COMPOSITION; 4700 ohms; ±5%; 1/4 watt MIL type RC07GF472J STODDART No. 11693-472
R221	RESISTOR, VARIABLE, COMPOSITION 100,000 ohms Clarostat type 44-100k-W STODDART No. 12736
R222	RESISTOR, FIXED, COMPOSITION; 10,000 ohms; ±5%; 1/4 watt MIL type RC07GF103J STODDART No. 11693-103
R223	Same as R213
R224	Same as R214
R225	RESISTOR, FIXED, COMPOSITION; 5.6 ohms; ±5%; 1/4 watt MIL type RC07GF5R6J STODDART No. 11693-5R6
S201	SWITCH, ROTARY; 3 Section; 7-position STODDART No. 12752
S202	SWITCH, SLIDE; DPDT; 1/2 amp - 50 V Calectro Corp. No. 2-105P STODDART No. 12538
S203	SWITCH, TOGGLE; Arrow, Hart and Hegeman type 83073 STODDART No. 12639

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